

# Maximizing the Investment from Your Software Product Portfolio

Linda Northrop

Software Engineering Institute  
Carnegie Mellon University  
Pittsburgh, PA 15213-2612



Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE <b>08 NOV 2010</b>		2. REPORT TYPE		3. DATES COVERED <b>00-00-2010 to 00-00-2010</b>	
4. TITLE AND SUBTITLE <b>Maximizing the Investment from Your Software Product Portfolio</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Carnegie Mellon University ,Software Engineering Institute,Pittsburgh,PA,15213</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>53</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

# Today's Speaker

Linda Northrop is director of the Research, Technology, and System Solutions Program at the Software Engineering Institute where she leads the work in architecture-centric engineering, software product lines, systems of systems, and ultra-large-scale systems.

She is coauthor of *Software Product Lines: Practices and Patterns*. She recently led a year long study including leaders in the software community to define technical and social challenges to the creation of ultra-large-scale systems that will evolve in the next generation. The group published the study report, *Ultra-Large-Scale Systems: The Software Challenge of the Future (ISBN 0-9786956-0-7)*.

Before joining the SEI, she was associated with both the United States Air Force Academy and the State University of New York as professor of computer science, and with both Eastman Kodak and IBM as a software engineer.



# Polling Question 1

**How did you hear about this webinar?**

Email invitation from the SEI

SEI Website

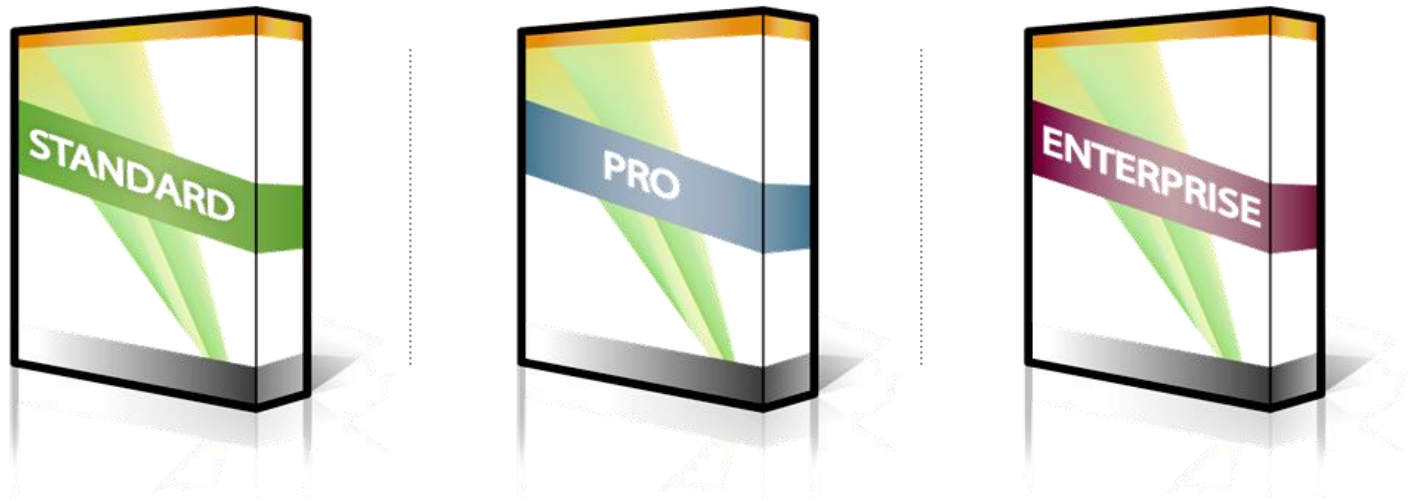
Website with webinar calendar (ie [www.webinar-directory.com](http://www.webinar-directory.com))

Social Media site ( LinkedIn, Twitter)

SEI Member Bulletin



# Few Systems Are Unique



Most organizations produce families of similar systems, differentiated by features.

A reuse strategy makes sense.

Traditional reuse strategies have had little economic benefit.



# Polling Question 2

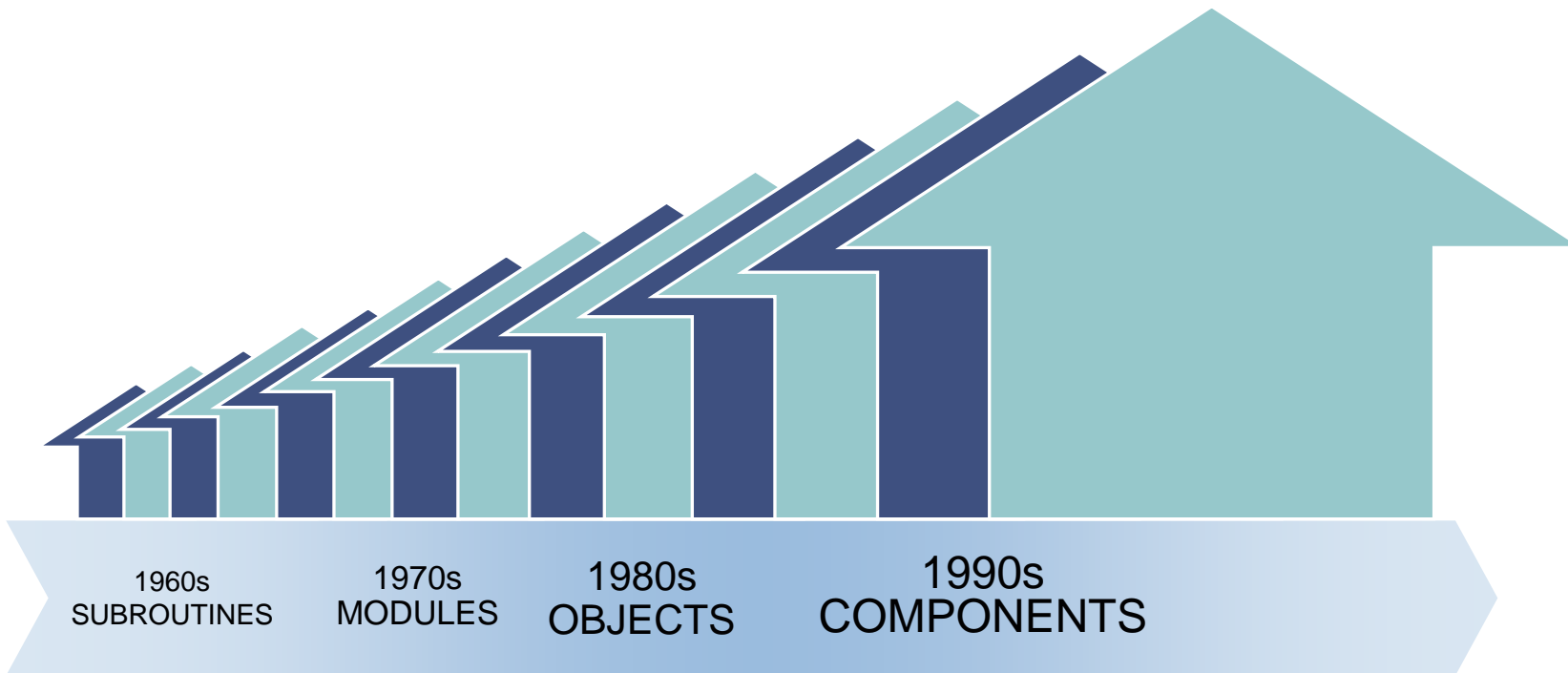
Does your organization have a portfolio that contains multiple distinct systems having similar features and capabilities?

1) Yes

2) No



# Reuse History



*Focus was small-grained, opportunistic, and technology-driven.  
Results did not meet business goals.*



# Strategic Reuse is Needed for Business Benefits





# What Is A Software Product Line?

A *software product line* is a set of software-intensive systems sharing a common, managed set of features that satisfy the specific needs of a particular market segment or mission and that are developed from a common set of core assets in a prescribed way.

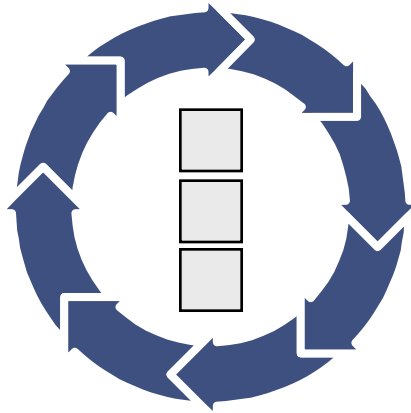
- a new application of a proven concept
- an innovative, growing concept in software engineering



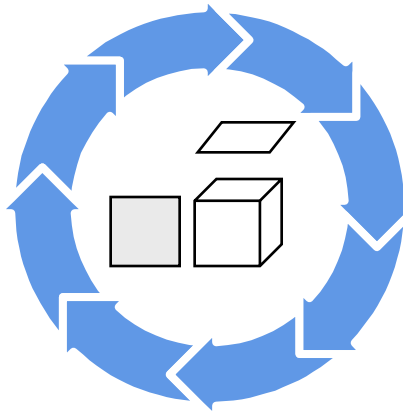
# The Key Concepts

---

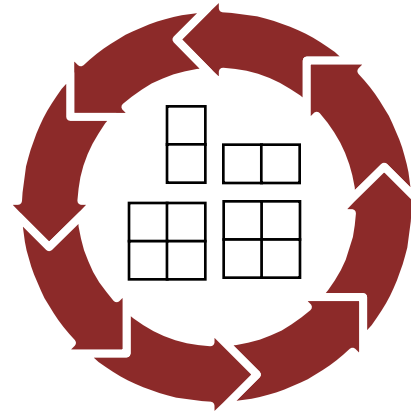
**Use of a core  
asset base**



**in production**

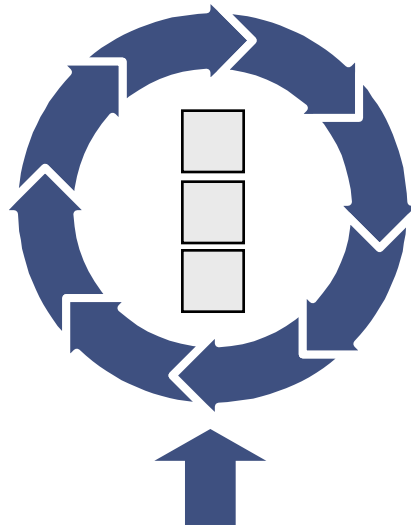


**of a related  
set of products**



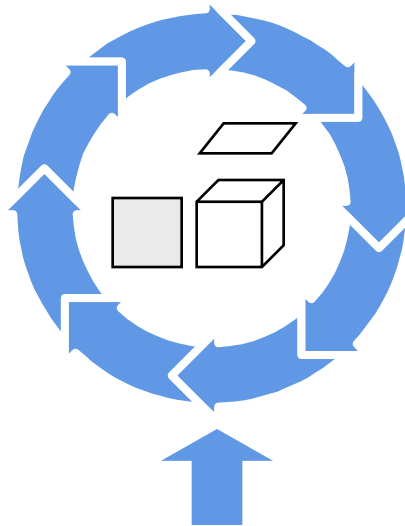
# The Key Concepts

**Use of a core  
asset base**



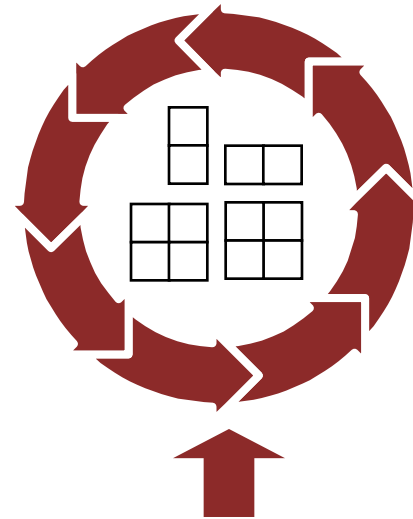
**Architecture**

**in production**



**Production Plan**

**of a related  
set of products**



**Scope Definition  
Business Case**



# Polling Question 3

---

Are you familiar with the concept of software product lines?

- 1) Have never heard of it.
- 2) Have heard about it but never tried it.
- 3) Have tried it but have not been too successful.
- 4) Have tried it and was successful.



# Widespread Use of Software Product Lines

Successful software product lines have been built for families of among other things

- mobile phones
- command and control ship systems
- satellite ground station systems
- avionics systems
- command and control/situation awareness systems
- pagers
- engine control systems
- mass storage devices
- billing systems
- web-based retail systems
- printers
- consumer electronic products
- acquisition management enterprise systems
- financial and tax systems
- medical devices
- farm fish management software



# Specific Examples - 1



Feed control and farm management software



Bold Stroke Avionics

**E-COM Technology Ltd.**

Medical imaging workstations



Firmware for computer peripherals



**Lucent Technologies**  
Bell Labs Innovations

5ESS telecommunications switch



**Asea Brown Boveri**

Gas turbines, train control, semantic graphics framework



**Dialect**

Internet payment gateway infrastructure products

**ERICSSON**



AXE family of telecommunications switches



Elevator control systems

**NOKIA**

Mobile phones, mobile browsers, telecom products for public, private and cellular networks



Computer printer servers, storage servers, network camera and scanner servers



Customized solutions for transportation industries



Software for engines, transmissions and controllers



RAID controller firmware for disk storage units



Interferometer product line



**Software Engineering Institute**

**Carnegie Mellon**

Linda Northrop

© 2010 Carnegie Mellon University

# Specific Examples - 2

## PHILIPS

High-end televisions,  
PKI telecommunications switching  
system, diagnostic imaging equipment

## Rockwell Collins

Commercial flight control system avionics,  
Common Army Avionics System (CAAS),  
U.S. Army helicopters

## sybian

EPOC operating system



Test range facilities

## RICOH

Office appliances

## SALION™

TARGET. WIN. DELIVER.™

Revenue acquisition  
management systems

## TELVENT

Industrial supervisory control  
and business process  
management systems



Command and  
control simulator for  
Army fire support

## BOSCH



Automotive gasoline  
systems

## SIEMENS

Software for viewing and  
quantifying radiological images



Climate and flue gas  
measurement devices



Support software



## MOTOROLA

Pagers product line



# Real World Motivation

---

Organizations use product line practices to:

- achieve large scale productivity gains
- improve time to market
- maintain market presence
- sustain unprecedented growth
- achieve greater market agility
- compensate for an inability to hire
- enable mass customization
- get control of diverse product configurations
- improve product quality
- increase customer satisfaction
- increase predictability of cost, schedule, and quality





# Cummins Inc.: Diesel Control Systems

---

Over 20 product groups with over 1,000 separate engine applications

- Product cycle time was slashed from 250 person-months to a few person-months.
- Build and integration time was reduced from one year to one week.
- Quality goals are exceeded.
- Customer satisfaction is high.
- Product schedules are met.



# Second Generation Product Lines

Cummins launched a Core II product line

- not from emergency business needs, as was Core I
- from a mature realization that the organization could do better

Core II includes

- a new core asset base
- newly derived products
- a new product line process
- a new production method, strategy, and plan
- a new organizational structure
- a new operational concept
- a powerful, new toolset



*Core II is meeting its goals.*

*It is a much fuller and more mature product line capability.*



# Software Product Lines Today at Cummins



The overall impact of a software product line approach on Cummins as measured by Core II results includes

- freed up resources (time, money, and people) to invest in new technologies and state-of-the-art tools and simulation capabilities
- an all-time high in product quality
- continuously shrinking time to market
- an ability to handle increased breadth and complexity of products
- an ability to outpace its market rivals

Product lines have now become institutionalized at Cummins.



# Software Product Lines Value Proposition

The systematic use of software product line practices results in significant organizational benefits including

- increased quality
  - by as much as 10x
- decreased cost
  - by as much as 60%
- decreased labor needs
  - by as much as 87%
- decreased time to market (to field, to launch...)
  - by as much as 98%
- ability to move into new markets
  - in months, not years



# The Value of Options

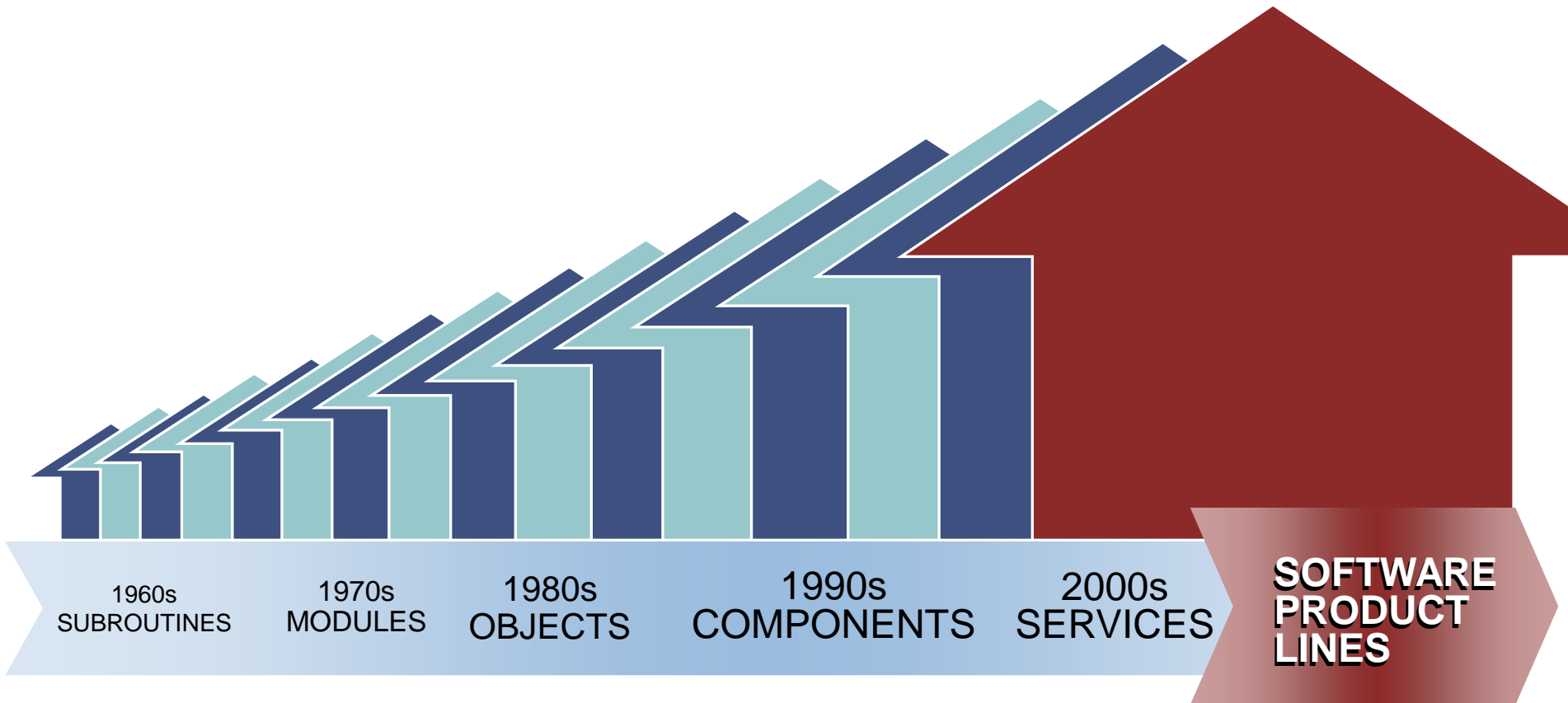
---

A software product line approach provides options to future market opportunities.

- The exact opportunities and their certainty are impossible to predict.
- Organizations need a way to conduct product experiments in low-cost, low-risk ways.
- Software product lines permit those kind of experiments through predefined variation points that can be exercised to meet new needs.



# Reuse History: From Ad Hoc To Systematic



# Software Product Lines Are Not

---

Clone and own: single-system development with reuse

- modifying code as necessary for the single system only

Fortuitous small-grained reuse

- reuse libraries containing algorithms, modules, objects, or components

Just component-based or service-based development

- selecting components or services from an in-house library, the marketplace, or the Web with no architecture focus

Just versions of a single product

- rather, simultaneous release and support of multiple products

Just a configurable architecture

- a good start, but only part of the reuse potential

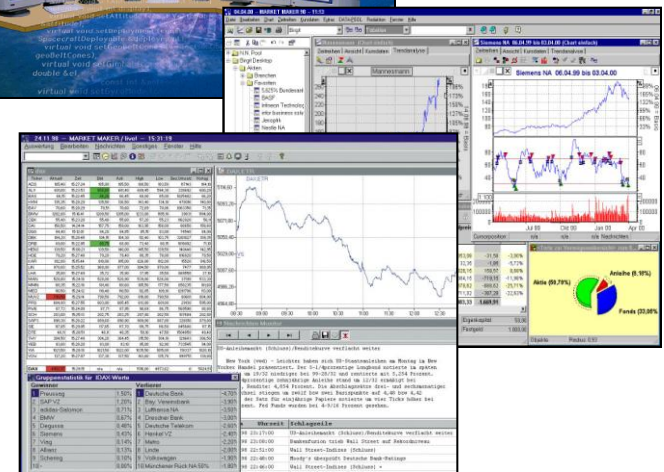
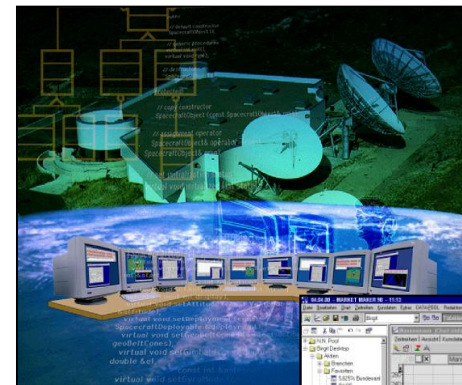
Just a set of technical standards

- constraining choices without an architecture-based reuse strategy



# Software Product Lines Are

Software product lines involve strategic, planned reuse that yields predictable results.





# Polling Question 4

---

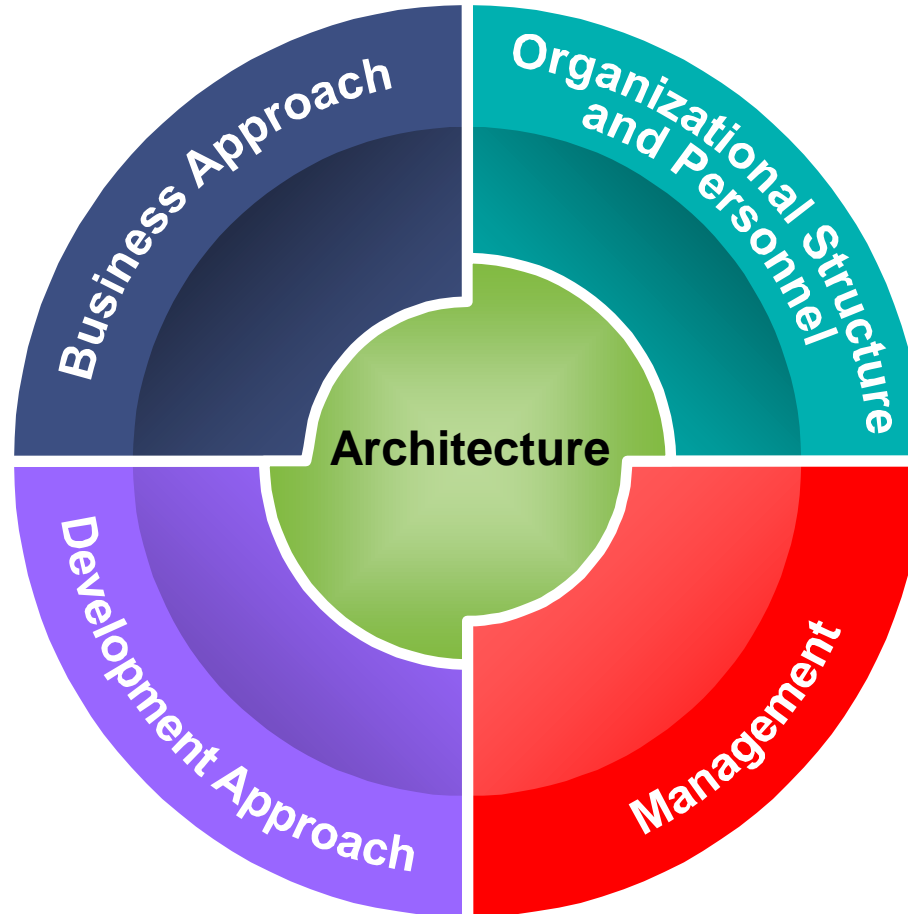
Do you use a form of software reuse at your organization?

- 1) clone and own
- 2) reuse library or repository
- 3) component-based or service-based approaches
- 4) application frameworks or standard architectures
- 5) some combination of the above



# Necessary Changes

---



*The product line architecture is central to success.*



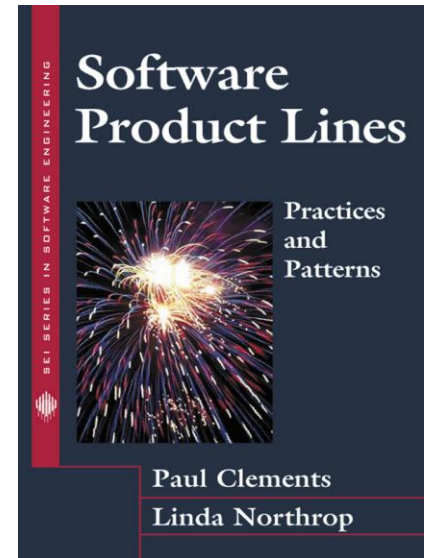
# The SEI Framework For Software Product Line Practice<sup>sm</sup>

The SEI Framework for Software Product Line Practice is a conceptual framework that describes the essential activities and twenty-nine practice areas necessary for successful software product lines.

The Framework, originally conceived in 1998, is evolving based on the experience and information provided by the community.

Version 4.0 –  
in *Software Product Lines: Practices and Patterns*

Version 5.0 –  
<http://www.sei.cmu.edu/productlines/framework.html>



# Three Essential Activities

All three activities are interrelated and highly iterative.

There is no “first” activity.

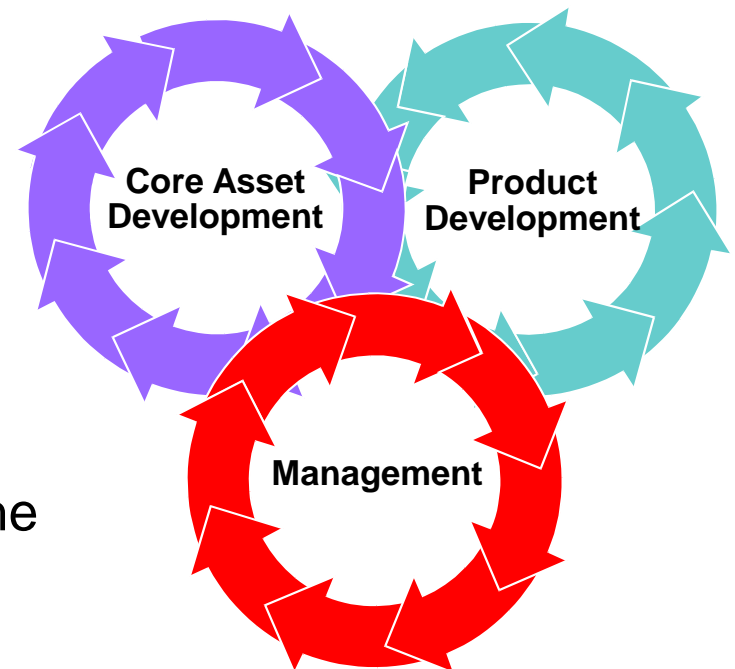
- In some contexts, existing products are mined for core assets.
- In others, core assets may be developed or procured for future use.

There is a strong feedback loop between the core assets and the products.

Strong management at multiple levels is needed throughout.

Management oversees core asset and product development.

Management orchestrates all activities and processes needed to make the three essential activities work together.



# Driving the Essential Activities

Supporting the essential activities are essential practices that fall into practice areas. A **practice area** is a body of work or a collection of activities that an organization must master to successfully carry out the essential work of a product line.



## Three Categories Of Practice Areas

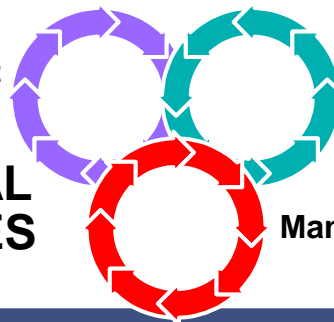
The practice areas represent common activities in software development that are adapted to the needs of a product line approach.



# Framework Version 5.0

ESSENTIAL  
ACTIVITIES

Core Asset  
Development



Product  
Development

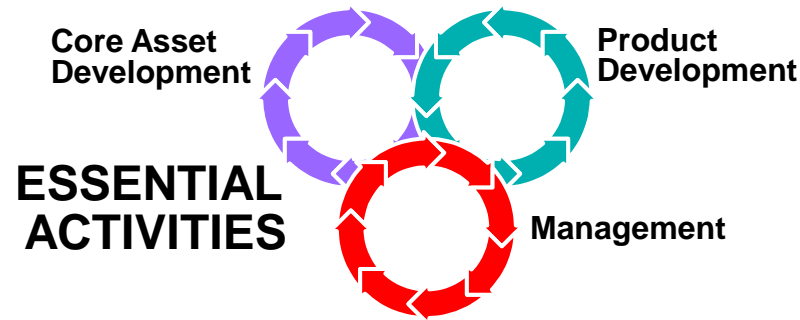
Management

## PRACTICE AREAS

Software Engineering	Technical Management	Organizational Management
Architecture Definition	Configuration Management	Building a Business Case
Architecture Evaluation	Make/Buy/Mine/Commission Analysis	Customer Interface Management
Component Development	<i>Measurement and Tracking</i>	Developing an Acquisition Strategy
Mining Existing Assets	<i>Process Discipline</i>	Funding
Requirements Engineering	Scoping	Launching and Institutionalizing
Software System Integration	Technical Planning	Market Analysis
Testing	Technical Risk Management	Operations
Understanding Relevant Domains	Tool Support	Organizational Planning
<i>Using Externally Available Software</i>	<div> <p>Key:</p> <p><i>New Name and Substantial Change</i></p> <p>Substantial Change</p> </div>	Organizational Risk Management
		Structuring the Organization
		Technology Forecasting
		Training



# Dilemma: How Do You Apply The 29 Practice Areas?



## PRACTICE AREAS

Software Engineering

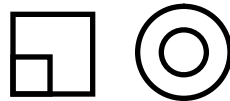
Technical Management

Organizational Management

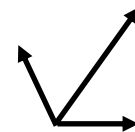
## GUIDANCE



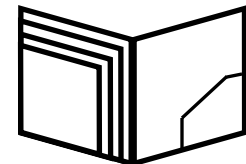
Case Studies



Patterns



Probe



Curriculum



# Case Studies

**CelsiusTech** – CMU/SEI-96-TR-016

<http://www.sei.cmu.edu/publications/documents/01.reports/96.tr.016.html>

**Cummins, Inc.** *Software Product Lines: Practices and Patterns*

**Market Maker** *Software Product Lines: Practices and Patterns*

**NRO/Raytheon** – CMU/SEI-2001-TR-030

<http://www.sei.cmu.edu/publications/documents/01.reports/02tr030.html>

**NUWC** – CMU/SEI-2002-TN-018

<http://www.sei.cmu.edu/publications/documents/02.reports/02tn018.html>

**Salion, Inc.** – CMU/SEI-2002-TR-038

<http://www.sei.cmu.edu/publications/documents/02.reports/02tr038.html>

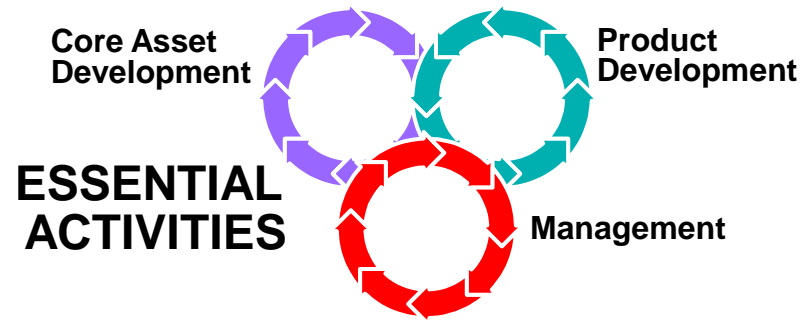
**U.S. Army** – CMU/SEI-2005-TR-019

<http://www.sei.cmu.edu/publications/documents/05.reports/05tr019.html>





# Help To Make It Happen



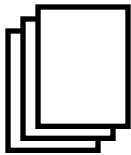
## PRACTICE AREAS

Software Engineering

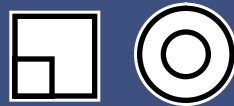
Technical Management

Organizational Management

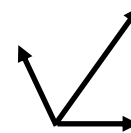
## GUIDANCE



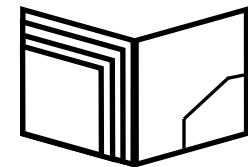
Case Studies



Patterns



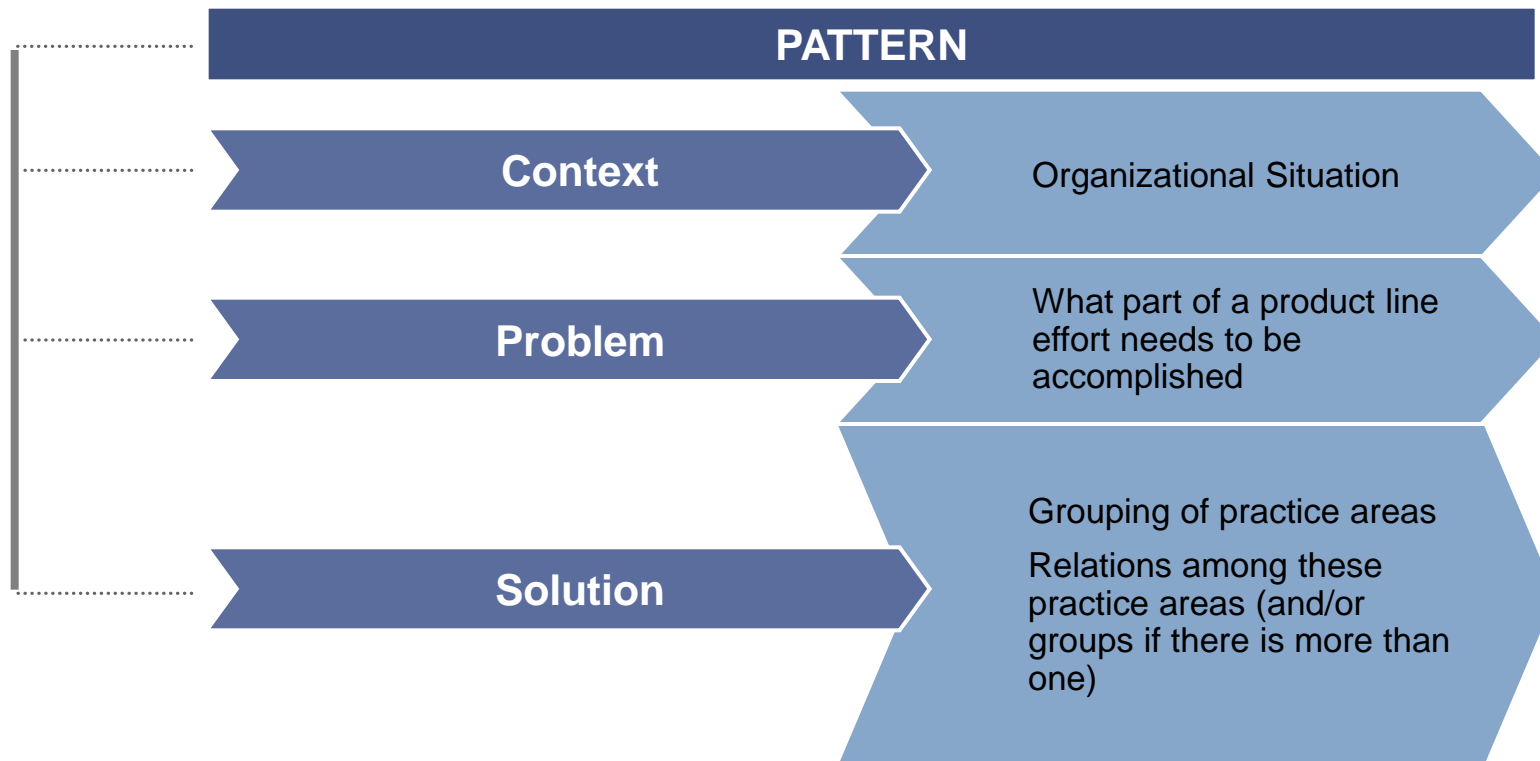
Probe



Curriculum



# Software Product Line Practice Patterns

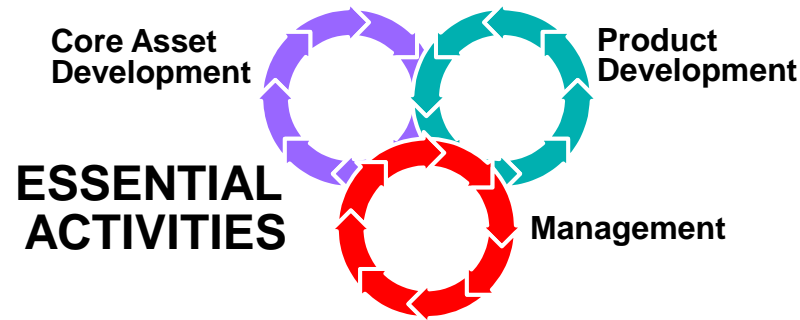


# Current Set Of Patterns

Pattern	Variants
Assembly Line	
Cold Start	Warm Start
Curriculum	
Each Asset	Each Asset Apprentice Evolve Each Asset
Essentials Coverage	
Factory	Adoption Factory
In Motion	
Monitor	
Process	Process Improvement
Product Builder	Product Gen
Product Parts	Green Field Barren Field Plowed Field
What to Build	Analysis Forced March



# Help To Make It Happen



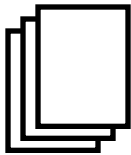
## PRACTICE AREAS

Software Engineering

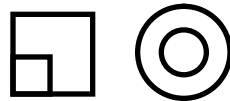
Technical Management

Organizational Management

## GUIDANCE



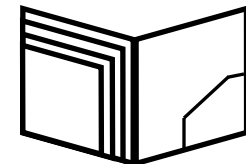
Case Studies



Patterns



Probe



Curriculum



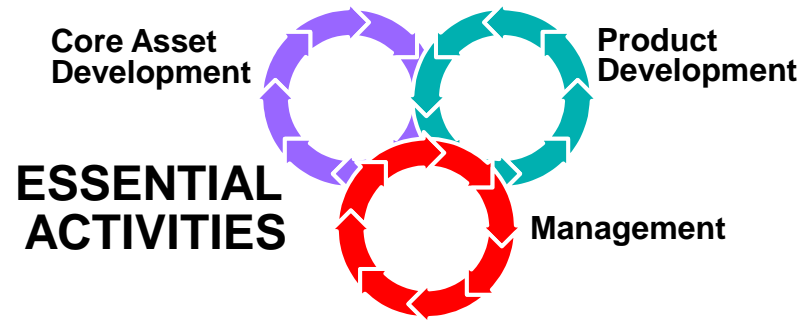
# What Is An SEI Product Line Technical Probe (PLTP)?

The SEI PLTP is a method for examining an organization's readiness to adopt or ability to succeed with a software product line approach.

- It is a diagnostic tool based on the SEI Framework for Software Product Line Practice.
- The 29 practice areas are the basis of data collection and analysis.



# Help To Make It Happen



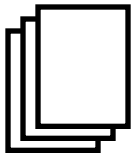
## PRACTICE AREAS

Software Engineering

Technical Management

Organizational Management

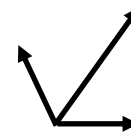
## GUIDANCE



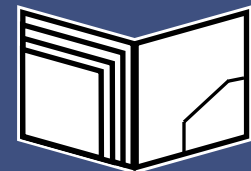
Case Studies



Patterns



Probe



Curriculum



# The SEI Software Product Line Curriculum

## Three Certificate Programs

Software Product Line Professional	PLTP Team Member	PLTP Leader
------------------------------------	------------------	-------------

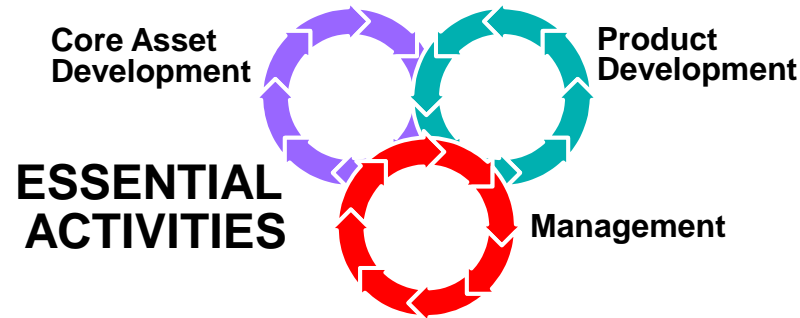
### Five Courses

Software Product Lines	✓	✓	✓
Adopting Software Product Lines	✓	✓	✓
Developing Software Product Lines	✓	✓	✓
PLTP Team Training		✓	✓
PLTP Leader Training			✓
PLTP Lead Observation			✓

✓ : course required to receive certificate



# Adding An Adoption Roadmap



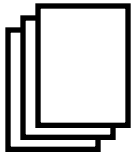
## PRACTICE AREAS

Software Engineering

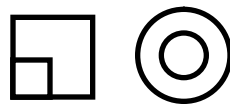
Technical Management

Organizational Management

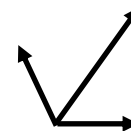
## GUIDANCE



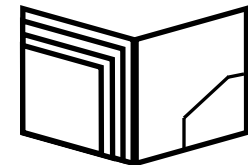
Case Studies



Patterns



Probe



Curriculum

## ADOPTION FACTORY





# The Product Line Adoption Endgame

---

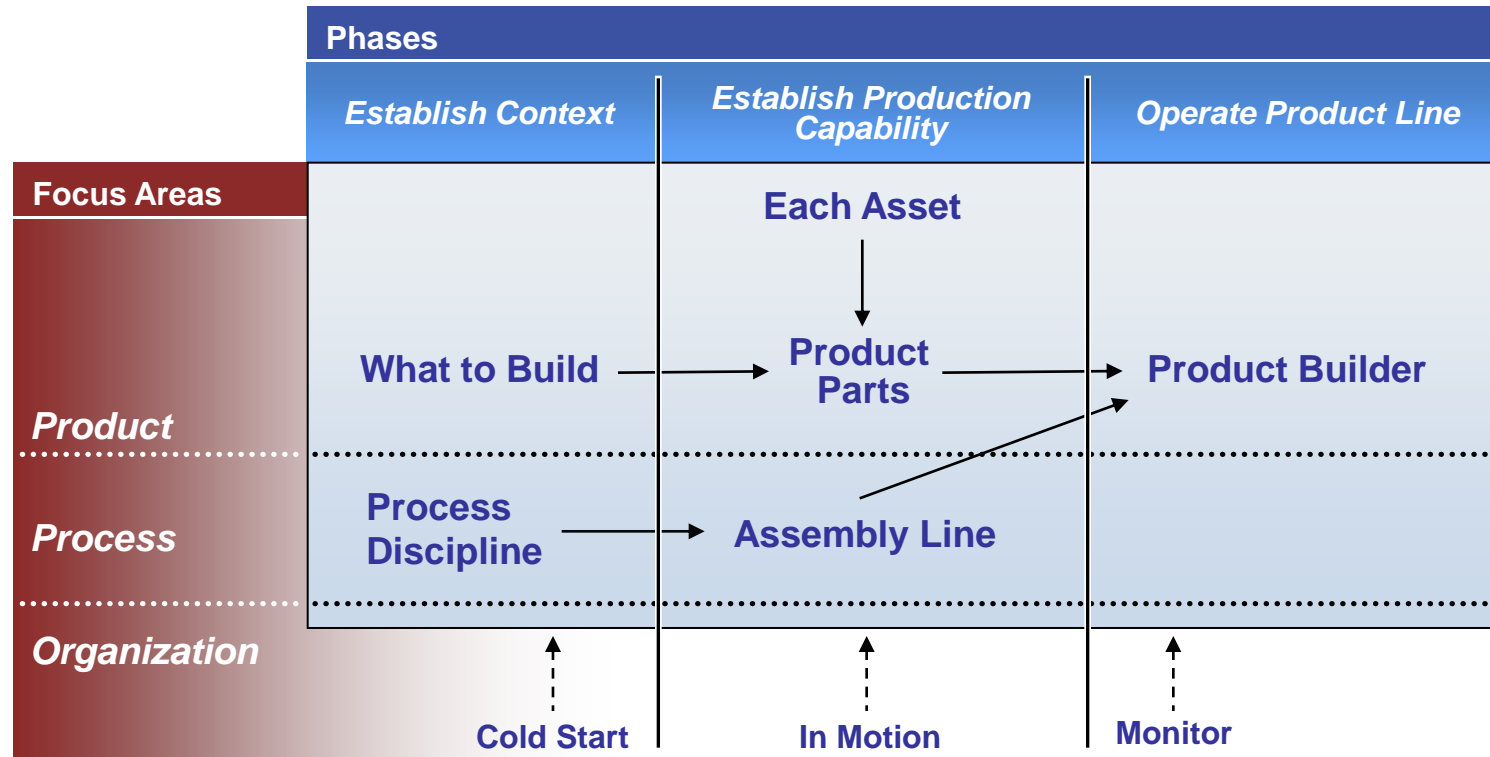
To have an **operational software product line**.

To do that, an organization must

- have
  - a core asset base
  - supportive processes and organizational structures
- develop products from that asset base in a way that achieves business goals
- prepare itself to institutionalize product line practices



# The SEI Adoption Factory Pattern



→  
Informs and information flow

- - - →  
Supports



# Associated Practice Areas

	Establish Context	Establish Production Capability	Operate Product Line
Product	<ul style="list-style-type: none"> <li>• Marketing Analysis</li> <li>• Understanding Relevant Domains</li> <li>• Technology Forecasting</li> <li>• Building a Business Case</li> <li>• Scoping</li> </ul>	<ul style="list-style-type: none"> <li>• Requirements Engineering</li> <li>• Architecture Definition</li> <li>• Architecture Evaluation</li> <li>• Mining Existing Assets</li> <li>• Component Development</li> <li>• Using Externally Available Software</li> <li>• Software System Integration</li> <li>• Testing</li> </ul>	<ul style="list-style-type: none"> <li>• Requirements Engineering</li> <li>• Architecture Definition</li> <li>• Architecture Evaluation</li> <li>• Mining Existing Assets</li> <li>• Component Development</li> <li>• Using Externally Available Software</li> <li>• Software System Integration</li> <li>• Testing</li> </ul>
Process	<ul style="list-style-type: none"> <li>• Process Discipline</li> </ul>	<ul style="list-style-type: none"> <li>• Make/Buy/Mine/Commission</li> <li>• Configuration Management</li> <li>• Tool Support</li> <li>• Measurement and Tracking</li> <li>• Technical Planning</li> <li>• Technical Risk Management</li> </ul>	
Organization	<ul style="list-style-type: none"> <li>• Launching and Institutionalizing</li> <li>• Funding</li> <li>• Structuring the Organization</li> <li>• Operations</li> <li>• Organizational Planning</li> <li>• Customer Interface Management</li> <li>• Organizational Risk Management</li> <li>• Developing an Acquisition Strategy</li> <li>• Training</li> </ul>	<ul style="list-style-type: none"> <li>• Launching and Institutionalizing</li> <li>• Funding</li> <li>• Structuring the Organization</li> <li>• Operations</li> <li>• Organizational Planning</li> <li>• Customer Interface Management</li> <li>• Organizational Risk Management</li> <li>• Developing an Acquisition Strategy</li> <li>• Training</li> </ul>	<ul style="list-style-type: none"> <li>• Measurement and Tracking</li> <li>• Technical Risk Management</li> <li>• Organizational Risk Management</li> <li>• Customer Interface Management</li> <li>• Organizational Planning</li> </ul>



# What's Different About Reuse With Software Product Lines?

- Business dimension
- Iteration
- Architecture focus
- Preplanning
- Process and product connection



# Polling Question 5

If you have been involved in a product line effort, where was the biggest challenge?

- 1) architecture
- 2) variation management
- 3) funding
- 4) management support
- 5) other



# Remaining Challenges

Variation mechanisms and variation management

---

Automating all or part of the production process

---

Lowering adoption cost

---

Distributed development and evolution

---

Scaling to systems of systems and ultra-large-scale systems

---



# Challenges - Emerging Solutions

Variation mechanisms and variation management

AOP/AOSD

SOA

End-User Programming

Automating all or part of the production process

MDA

DSL

DDD

Generative Programming

Lowering adoption cost

Agile, Phased Approaches

Tool Support

Distributed development and evolution

Open Source Models

Collaborative Environments

Virtual Worlds

Scaling to systems of systems and ultra-large-scale systems

Product lines reduce interoperability issues



# Product Lines of the Future

Will harness new and emerging technologies

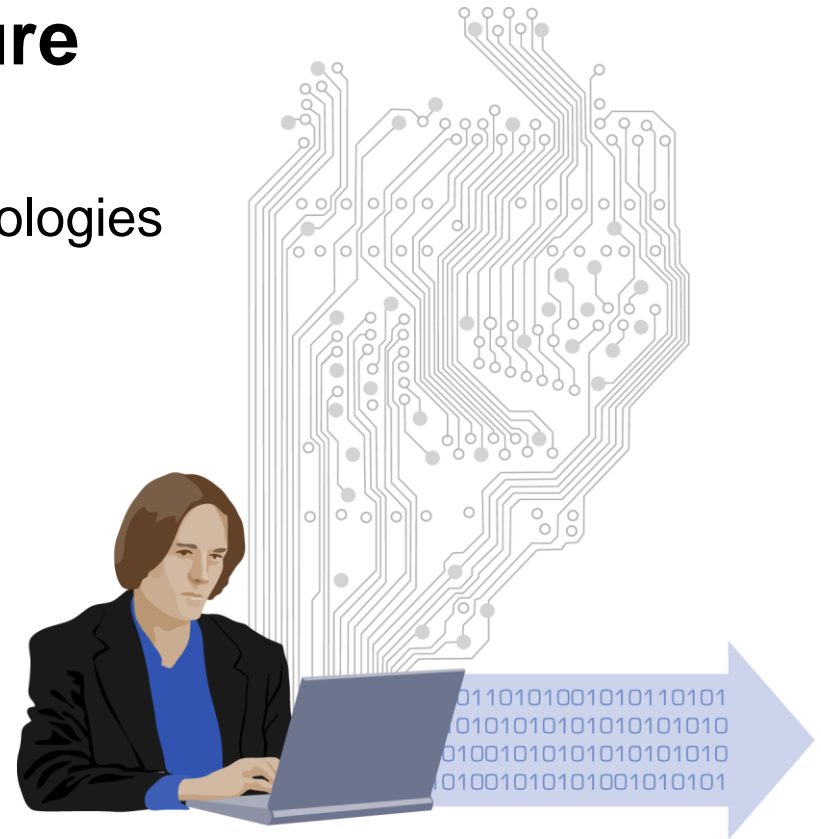
- metadata
- automated derivation
- SOA
- end-user programming

and new forms of collaboration

- cooperative models
- globalization
- virtual worlds
- collaborative environments

to make product lines more doable, pliable, and dynamic.

Tomorrow's product lines will accrue even greater benefits than those already demonstrated.





# Summary of SEI Contributions

## Models and Guidance

- *A Framework for Software Product Line Practice<sup>SM</sup>*
- *Software Product Line Acquisition: A Companion to A Framework for Software Product Line Practice*
- Product line practice patterns
- Product line adoption roadmap
- Pedagogical product line

## Methods and Technology

- product line analysis
- architecture definition, documentation, evaluation (ATAM®), and recovery
- mining assets
- production planning
- Structured Intuitive Model for Product Line Economics (SIMPLE)
- Product Line Technical Probe<sup>SM</sup> (PLTP<sup>SM</sup>)
- Product Line Quick Look (PLQL)
- Interactive workshops in product line measurement, variability management, product line management
- Prediction-enabled component technology

## Book

### ***Software Product Lines: Practices and Patterns***

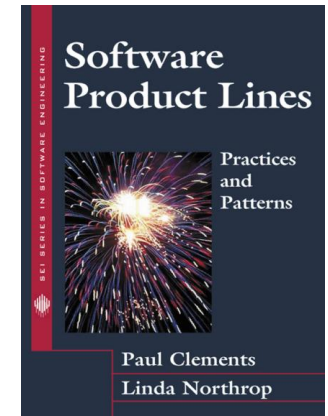
### **Curriculum and Certificate Programs**

- Five courses and three certificate programs
- Product Line Executive Seminar

### **Conferences and Workshops**

- SPLC 1, SPLC2, SPLC 2004; SPLC 2006; SPLC 2009; Workshops 1997 - 2005; Army Product Line Workshop 2007; Army Product Line Workshop 2009

### **Technical Reports, publications, and Web site**



### **SPLC | Software Product Lines Conferences**



# Ongoing SEI Product Line Research

---

## Product derivation

- variation mechanisms
- production plan definition and implementation
- product line production including automated derivation

## Product line adoption strategies

- economic models
- acquisition strategies

## Adapting product line concepts to exploit new technologies and serve new contexts

- system of systems
- service-oriented architectures
- open source
- globalization
- ultra-large scale systems

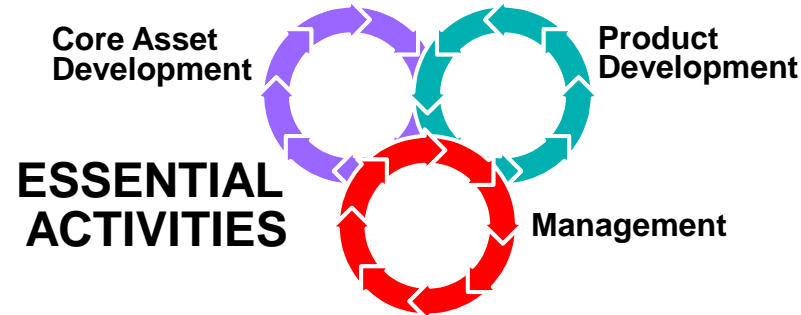


# In A Nutshell

Software product lines epitomize the concept of strategic, planned reuse.

The product line concept is about more than a new technology. It is a new way of doing one's software business.

There are essential product line activities and practices areas as well as product line patterns to make the move to product lines more manageable.



PRACTICE AREAS		
Software Engineering	Technical Management	Organizational Management



# Final Notes



Research in software product lines was inspired by the proven benefits of product line approaches in manufacturing, and was buoyed by the advent of object and component technology.

The SEI has been a leader in developing a body of knowledge and a set of standard models for software product lines.

Early product line adopters, like Cummins, Inc., are now on second generation product lines that have resulted in even far greater benefits.

Service-oriented and model-driven approaches, as well as developments in collaborative philosophies and environments, are extending the power of product line practice in exciting new ways.

Future product lines will make much greater use of dynamic variation and enable mass customization in ways not achievable today.



## NO WARRANTY

THIS CARNEGIE MELLON UNIVERSITY AND SOFTWARE ENGINEERING INSTITUTE MATERIAL IS FURNISHED ON AN "AS-IS" BASIS. CARNEGIE MELLON UNIVERSITY MAKES NO WARRANTIES OF ANY KIND, EITHER EXPRESSED OR IMPLIED, AS TO ANY MATTER INCLUDING, BUT NOT LIMITED TO, WARRANTY OF FITNESS FOR PURPOSE OR MERCHANTABILITY, EXCLUSIVITY, OR RESULTS OBTAINED FROM USE OF THE MATERIAL. CARNEGIE MELLON UNIVERSITY DOES NOT MAKE ANY WARRANTY OF ANY KIND WITH RESPECT TO FREEDOM FROM PATENT, TRADEMARK, OR COPYRIGHT INFRINGEMENT.

Use of any trademarks in this presentation is not intended in any way to infringe on the rights of the trademark holder.

This Presentation may be reproduced in its entirety, without modification, and freely distributed in written or electronic form without requesting formal permission. Permission is required for any other use. Requests for permission should be directed to the Software Engineering Institute at [permission@sei.cmu.edu](mailto:permission@sei.cmu.edu).

This work was created in the performance of Federal Government Contract Number FA8721-05-C-0003 with Carnegie Mellon University for the operation of the Software Engineering Institute, a federally funded research and development center. The Government of the United States has a royalty-free government-purpose license to use, duplicate, or disclose the work, in whole or in part and in any manner, and to have or permit others to do so, for government purposes pursuant to the copyright license under the clause at 252.227-7013.



# Questions – Now Or Later

## Linda Northrop

Director, Research, Technology, and System Solutions Program

Telephone: 412-268-7638

Email: [lmn@sei.cmu.edu](mailto:lmn@sei.cmu.edu)

## U.S. Mail:

Software Engineering Institute

Carnegie Mellon University

4500 Fifth Avenue

Pittsburgh, PA 15213-3890



## World Wide Web:

<http://www.sei.cmu.edu/productlines>

SEI Fax: 412-268-5758

